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THE MODE OF EXTRICATION OF SILKWORM MOTHS FROM THEIR COCOONS.

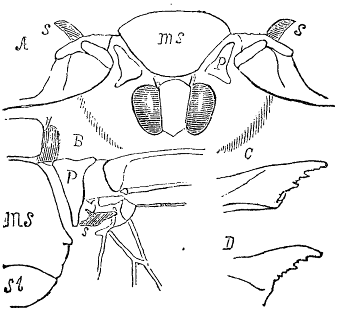
BY A. S. PACKARD, JR.

WITHOUT having made extended research in the literature of entomology, the only account which we have been able to find of the mode of extrication of the silkworm moths from their cocoons is that given by Kirby and Spence in their chapter on the pupa state of insects, vol. iii, pp. 280–283, which is quoted below, as it gives a summary of what was known up to the year 1828, while so far as we are aware nothing has since then been recorded on this interesting subject, except the observations of Mr. L. Trouvelot (AMERICAN NATURALIST, vol. i, pp. 33, 34); the brief statement in Lacordaire's Introduction a l'Entomology (1834, p. 201) being evidently based on Réaumur's observations.

The texture of the cocoon of the silkworm moth is uniform in every part, and the layers of silk are equally thick at both ends. The moth makes its way out by cutting or breaking these threads at the end opposite to its head; an operation which, as it destroys the continuity of the silk, those who breed these insects are particularly careful to guard against, by exposing the cocoon to heat sufficient to destroy the included pupa. The question is, what instruments does the moth employ to effect this? And this we are not able to answer satisfactorily. Malpighi asserts that the animal first wets the silk with a liquid calculated to dissolve the gum that connects the threads, and then employs its lengthened head to push them aside and make an opening. But, as Réaumur has observed, besides that so obtuse a part as the head of a moth is but ill-fitted to act as a wedge, we find the threads not merely pushed to each side, but actually cut asunder. He therefore infers that the eyes, which are the only hard organs of the head, are the instruments by which the threads are divided—their numerous minute facets serving the purpose of a fine file It should be observed, however, that Mr. Swayne confirms Malpighi's assertion that the silk worm does not cut but merely pushes aside the threads of its cocoon, and he informs us that he has proved the fact by unwinding a pierced cocoon, the thread of which was entire. Yet Réaumur's correctness cannot be suspected, and he affirms that from observation there can scarcely be a doubt that most of the threads are broken; which is further confirmed in an account of the breeding of silkworms published in the American Philosophical Transactions, in which it is expressly stated that cocoons out of which the fly has escaped cannot be wound. Analogy, it must be confessed, is against Réaumur's opinion, since other kinds of silkworms make their escape by means of a *fluid*. Thus we are informed by Dr. Roxburgh that *Attacus paphia* when prepared to assume the imago, discharges from its mouth a large quantity of liquid, with which the upper end of the case is so perfectly softened as to enable the moth to work its way out in a very short space of time, an operation which, he says, is always performed in the night. Perhaps the two opinions may be reconciled by supposing the silkworm first to moisten and then break the threads of its cocoon. In those that are of a slighter texture, a mere push against the moistened end is probably sufficient, and hence we find in so many newly-disclosed moths the hair in that part wet and closely pressed down. If it be apparently difficult for the silkworm moth to effect an opening in its cocoon, how much harder must seem the task of the puss moth (*Cerura vinula*) to pierce the solid walls of its wood-thickened case? Here the eyes are clearly incompetent; nor could any ordinary fluid assist their operation, for the gum which unites the ligneous particles is indissoluble in aqueous menstrua. You begin to tremble for the fate of the moth incarcerated in such an impervious dungeon, but without cause; what an *aqueous* solvent cannot effect, an *acid* is competent to, and with a bag of such acid our moth is furnished. The contents of this she pours out as soon as she has forced her head through the skin of the chrysalis, and upon the opposite end of the cocoon. The acid instantly acts upon the gum, loosens the cohesion of the grains of wood, and a very gentle effort suffices to push down what was a minute ago so strong a barrier.

Our attention was called to this subject by a rustling, cutting and tearing noise issuing from a cocoon of *Actias luna*, the large green swallow-tailed silkworm moth. On examination a sharp black point was seen moving to and fro, and then another, until both points had cut a rough irregular slit, through which the shoulders of the moth could be seen vigorously moving from side to side. The hole or slit was made in one or two minutes, and the moth worked its way at once out of the slit. The wings at this time being very small and flabby, and the shoulders being alternately much raised, the points stuck up far enough to cut or saw through the cocoon. The wings were at first of a deep buff yellow, but in half an hour after, the wings began to expand more than before and to turn green. The black points, when the wings are fully expanded, can be detected, not being entirely covered by the hairs at the base of the wing. In this case no fluid was seen to exude from the mouth, and the cocoon was perfectly dry.

On examining two dry denuded specimens of *A. luna*, the black spine was seen at the base of each fore wing, and external to but opposite the end of each patagium. The spine, which may be called the *sector coconis*, is figured by Mr. J. S. Kingsley in the accompanying cut. A represents the specimen of *A. luna* which came out of the cocoon and died with the wings not expanded. It represents a front view of the moth with the shoulders elevated and the rudimentary wings hanging down; *s*, the cocoon-cutter; *p*, patagium. B represents another specimen with fully developed wings; *ms*, scutum; *st*, scutellum of the mesothoracic segment; *s*, the cocoon-cutter, which is evidently a modification of one of the pieces at the base of the fore wings; it is surrounded by membrane, allowing free movement. C and D are different views of the spine considerably magnified, showing the five or six irregular teeth on the cutting edge, the spine being sharp, curved and conical. It will be seen that it acts like a rude saw.



Cocoon cutter of the *Luna* moth.

A number of other members of the sub-family *Attaci* were examined, and this cocoon-cutter was found to be present in all. In *Telea polyphemus* it is large and well developed, though according to Mr. Trouvelot the moth does not apparently need it; still, fresh observations directed to this point may show that it is put to active use. In *Callosamia promethea, Platysamia cecropia*, and *P. gloverii* it is rather small. Its use in this latter genus, where the cocoon is left partly open at one end does not seem necessary, still it may come in play while the moth is pushing through the threads which it first encounters. In *Samia cynthia*, and an *Attacus* from Nicaragua, and *Attacus amazonia* Pack. from Pebas, Peru, the cocoon-cutters are rather small, about one-half as large in proportion as in *A. luna*, yet the spines are black. It is large and well marked in the European *Saturnia pavonia-minor* and *Endromis versicolora* Linn.

In *Bombyx mori* the spines are not well marked, and they are quite different from those in the *Attaci*. There are three sharp points, being acute angles of the pieces at the base of the wing. Their relations need examining in alcoholic specimens which we have not at hand. Still it must be these saws which perform the cutting described by Réaumur. No such spines are present in *Eacles imperialis.*

These observations have been thrown together with the hope of stimulating fresh observations among those raising silkworm moths. Particular attention should be paid to *Telea polyphemus*, in which the cocoon cutter is so well developed, and where its use would seem to be dispensed with, according to the observations of Mr. Trouvelot.

Since the foregoing lines were put in type, I have observed several *Platysamia gloverii* and one *P. columbia* either in the act of making its way out of its cocoon or immediately after. In no case was any cutting or tearing noise heard, though the cocoons were all within a foot and a half of my head, on my study table. I do not believe that the cocoon-cutters, though well developed, are used at all. (In fact, just as I had written the preceding sentence, a male came out of its cocoon, and my attention was first called to it by the rustling it made in creeping over the loose cocoons in the box; no noise was heard previous to its appearance on the outside of the cocoon.)

The inside of the cocoons of *Platysamia cecropia*, *columbia*, and *gloverii*, is glazed to within about a quarter of an inch of the anterior end of the cocoon, beyond it is rough and the silk fibres are capable of being distended and softened by the copious fluid poured out by the moth. The pupa splits along the whole back, sometimes to the end of the abdomen. Before issuing from the cocoon the wings expand much more in *P. gloverii* and *columbia* than in *A. luna;* at least just as the moths work their way out of the cocoon, and before they are entirely extricated, the wings are nearly an inch long. They evidently pull themselves through the aperture by their legs. Previous to extrication they discharge from the mouth a fluid which moistens the silk threads, and also the hairs of the head and thorax, together with the antennæ. This is invariably the case. The insect must with difficulty draw itself through the aperture, which scarcely admits the little finger.

The wings expand fully in from fifteen to forty minutes, usually about thirty minutes, but the moths are not capable of flying for an hour or so after. The moth hangs suspended to some object, with the wings and antennæ drooping down. Though I hatched out several males and females at a time, at different periods, none united sexually, though the females laid eggs.

The cocoon of *P. gloverii* differs from that of *P. cecropia* in being perhaps tougher and paler, more glistening in hue, though of the same form and size. It it always quite distinguishable from that of *P. cecropia.* The cocoon of *P. columbia* only differs from that of *P. gloverii* in its smaller size, and the more distinct patches of silk material scattered on the outside; it is of the same form as in the two other species.

I am indebted to Mr. J. L. Barfoot for a number of cocoons of *P. gloverii*, from near Salt Lake City, Utah, and to Prof. C. H. Fernald and Mr. Anson Allen, of Orono, Maine, for the cocoons and imagoes of *P. columbia.*

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RECENT LITERATURE.

HUXLEY'S MANUAL OF THE ANATOMY OF INVERTEBRATED ANIMALS.[1]—The great advances, within the past ten years, in our knowledge of the anatomy of animals, renders the appearance of this book timely. No one is better fitted than Prof. Huxley to prepare such a manual, which should be authoritative, compact, clearly written, and catholic in its treatment. This book, together with Siebold's Anatomy of the Invertebrates, will form a condensed library for the teacher and student. Prof. Huxley has made a good innovation on the plan of similar books in introducing detailed and more or less illustrated accounts of the anatomy of common types of animals, so that with the aid of this manual the ordinary student can, in a measure, become his own teacher. As a body of well digested facts, clearly and elegantly stated, this book is without a rival.

The classification we should find some fault with, as we do with some of Prof. Huxley's work in this direction, owing, we think, to an inherent lack of perspective in the learned author's mind. For example, the Cœlenterates are described near the beginning of the book, and the Echinoderms near the end; the worms, crustacea, insects, the Polyzoa, Brachiopods and molluscs are then described, and finally we are led to the Echinoderms; the Ascidians coming last, the work closing with the *Peripatidea, Myzostomata, Enteropneusta, Chætognatha, Nematoidea, Physemaria, Acanthocephala* and *Dicyemida.* This arrangement may be in part accounted for by the fact that the book was apparently two years in going through the press, and two years has made a great difference in our knowledge of these last-named groups; but there is no good reason, it seems to us, for separating certain groups so far from those to which they are evidently allied, even

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[1] *A Manual of the Anatomy of Invertebrated Animals.* By THOMAS H. HUXLEY. New York. D. Appleton & Co. 12mo. With figures. $2.50.